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THE PHOTOELECTRIC PROPERTIES of Sb2Se3 THIN-FILM HETEROSTRUCTURES

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Sb_2Se_3 (antimony selenide) thin films are gaining attention for their potential in thin-film solar cells due to their favorable optoelectronic properties, including a suitable bandgap (~1-1.5 eV), high absorption coefficient, and relatively low toxicity compared to other materials like CdTe and CIGS. Antimony selenide compound exhibits a unique quasi-one-dimensional structure with chains of $(Sb_4Se_6)n$, which can influence carrier transport. For the fabrication of ZnSe/Sb2Se3 devices, close spaced sublimation method was used. In our study a Sb2Se3 source and a substrate are separated by a 2 cm distance in a controlled atmosphere 5×10-6 Torr, and the source is maintained at a higher temperature than the substrate. The low distance between the source and substrate reduces the loss probability of mass transport during sublimation. The Sb2Se3 source materials dissociate into Sb atoms and Se2 molecules which collide several times with gas molecules and then condense on the substrate surface. This process provides direct transport of each component of the source across the space to the substrate, and in most cases, the rate of transport is diffusion-limited. Both thin films were prepared by close space sublimation method. ZnSe and Sb2Se3 thin films were consecutively deposited onto ITO-coated glass substrates. A careful balance of substrate and source temperatures defines growth rate. The structural properties of Sb2Se3 are very sensitive to substrate temperature, therefore accurate control of Tsub is of significant importance. The thickness value of the ZnSe buffer layer was varied in the interval 400-900 nm, while for Sb2Se3 is taken ~ 2 μm. The substrates, purchased from Merck (Germany), had a 200 nm-thick ITO layer with a surface resistivity of 60 Ω/sq. As ohmic contact for Sb2Se3 was used Ag.
The photovoltaic characteristics of ZnSe/Sb2Se3 thin film solar cells were investigated through the wide band gap components at the room temperature (300 K) and 100 mW/cm2 illumination. The highest efficiency of 0.96 % was achieved for ZnSe/Sb2Se3 thin film solar cells with a thicker ZnSe buffer layer. The value of the open circuit voltage (Voc) and the current density (Jsc) achieve ~ 0.32 V and 5.39 mA/cm2, respectively. The fill factor (FF) is low in general, approximately 0.34. According to the theory the fill factor is influenced by the shunt (Rsh) and the series resistance (Rs), the saturated dark current density and the diode quality factor. Ohmic shunting paths, likely caused by pinholes and grain boundaries, are represented by the shunt resistance (Rsh) of 81 $\Omega\cdot cm^2$. The devices are having relatively high ideality factor compared to ideal values near 1, indicating high recombination pathways in the devices due to the effects of Rs and Rsh, and recombination at the ZnSe/Sb2Se3 interface, which partly explains the low Voc and FF parameters of the devices.

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Primary author: GADIAC, Ivan (Laboratory of Organic/Inorganic Material for Optoelectronics, Moldova State University, 60, A. Mateevici str., 2009, Chisinau, Moldova)

Presenter: GADIAC, Ivan (Laboratory of Organic/Inorganic Material for Optoelectronics, Moldova State University, 60, A. Mateevici str., 2009, Chisinau, Moldova)

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